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PARSONS ENGINEERING SCIENCE, INC.

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June 2, 1997

Major Ed Marchand
AFCEE/ERT
3207 North Road, Bldg 532
Brooks AFB, Texas 78235-5363

Subject: Results of Bioventing System Monitoring at Building 675
(LPST No. 98508), Fort Bliss, Texas
(Contract No. F41624-92-D-8036, Order 17 Option 1)

Dear Major Marchand:

This letter presents the results of the bioventing system monitoring performed by Parsons Engineering Science, Inc. (Parsons ES) during the week of 28 April 1997 at Building 675, located at Fort Bliss, Texas. Soil gas samples were collected, and *in situ* respiration testing was performed to assess the extent of remediation achieved during approximately 1 year of air injection bioventing at Building 675. The purpose of this letter is to summarize remediation activities to date, present the results of the April and May 1997 monitoring event and compare them with the results of the initial bioventing pilot test completed by Parsons ES in April 1996 (Parsons ES, 1996b), and to make recommendations for future remediation activities at Building 675.

Site Background

Building 675 was used as a gasoline service station from approximately 1951 to 1985 (Figure 1, attached). Two leaking petroleum storage tank (LPST) sites were investigated in the vicinity of Building 675. In 1991, an underground storage tank (UST) system that included three 10,000-gallon USTs and associated product piping was removed from just northeast of the building (EA Remediation Technologies, Inc., 1991). This UST system formerly contained gasoline, and was assigned LPST No. 98508 by the State of Texas. In 1994, a waste oil tank, assigned LPST No. 109924, was abandoned in place beneath the southern edge of the building. The focus of this remediation effort is LPST No. 98508, the site of the former three-tank gasoline UST system located northeast of Building 675 (Figure 1).

The UST excavation was approximately 35 feet by 50 feet, and extended to a depth of approximately 16 feet below ground surface (bgs). Another excavation extended to a length of 140 feet and to a depth of approximately 3 feet bgs along the north side of the pump islands for removal of ancillary equipment (e.g., fuel lines). Soil contamination was observed in the tank pit during removal actions, suggesting that an unknown amount of gasoline had been released into the soil from the UST system (EA Remediation Technologies, Inc., 1991). Overexcavation to remove all contaminated soils from the pit was attempted, but was

discontinued because the vertical extent of contamination exceeded the depth that could be excavated. The excavation was backfilled with clean fill material.

In April 1996, Parsons ES performed a bioventing pilot test at the site to determine the feasibility of this technology for enhancing the biodegradation of petroleum hydrocarbon contaminants remaining in site soils. The pilot test was performed according to procedures outlined in the bioventing protocol document (Hinchee *et al.*, 1992), and the site-specific work plan (Parsons ES, 1996a). One vent well (VW) and three soil vapor monitoring points (MPs) were installed in the contaminated vadose zone soils remaining at the site (Figure 1). A background MP, designated as MPBG, also was installed in uncontaminated soils approximately 200 feet north of the VW. During VW and MP installation in the former tank excavation area, petroleum-contaminated soils were observed from about 18 to 55 feet bgs. The VW was screened from 15 to 55 feet bgs. Perched water was encountered at a depth of approximately 48 feet bgs, and a low-permeability clay layer was encountered at approximately 55 feet bgs (Parsons ES, 1996b).

A 1-horsepower regenerative blower was installed for air injection into the VW. The radius of oxygen influence measured at the site was estimated to be at least 50 feet, at an average air injection flow rate of approximately 16.5 cubic feet per minute (cfm), or approximately 0.5 cfm per foot of screened interval in unsaturated soils. Further details on the initial pilot test results can be found in the Interim Bioventing Pilot Test Results Report (Parsons ES, 1996b). The blower system operated continuously until 28 March 1997, when it was shut down to prepare for Option 1 testing activities.

Comparison of Soil Analytical Data with Texas Risk-Based Criteria

During VW and MP installation in April 1996, soil samples were collected for submission to an analytical laboratory from MPA at depths of 37 and 38 feet bgs and 44 to 45 feet bgs, from MPB at depths of 24 to 25 feet bgs and 48 to 49 feet bgs, from MPC at depths of 23 to 24 feet bgs, and from the VW at depths of 45 to 46 feet bgs and 56.5 feet bgs. Two background soil samples also were collected from MPBG installed in uncontaminated soils. These samples were analyzed for total volatile and extractable petroleum hydrocarbons (TPH and TEH); volatile organic compounds (VOCs), including benzene, toluene, ethylbenzene, and xylenes (BTEX), polynuclear aromatic hydrocarbons (PAHs), and several physical and nutrient parameters. Table 1 (attached) summarizes the analytical results for these samples and compares these results to the Texas Natural Resource Conservation Commission (TNRCC, 1994) Petroleum Storage Tank Division risk-based soil criteria.

The results of the soil analyses indicate that Plan A levels (for soil concentrations protective of groundwater-beneficial use category I) were exceeded for toluene and chlorobenzene in the sample collected at 47 to 50 feet bgs in the MPB borehole. Benzene was not detected in any of the soil samples analyzed (Table 1), but its detection limit exceeded the Plan A criterion in samples MPA(37-38), MPA(44-45), and MPB(47-50), so it can not be concluded that benzene concentrations are below Plan A criteria.

Soil Gas Chemistry Results

Soil gas samples were collected for field screening and laboratory analysis on 29 April 1997, following approximately 1 month of bioventing system shutdown. Soil gas sampling results from this Option 1 testing event, as well as soil gas sampling results from the initial sampling event on 14 April 1996, are presented in Table 2 (attached). In both events, soil gas samples were collected from each MP and the VW and field-screened to assess soil gas concentrations of oxygen, carbon dioxide, and total volatile hydrocarbons (TVH). Soil gas samples collected from MPA-45, MPB-32, MPB-45, and MPC-32 were submitted under chain-of-custody control to Air Toxics, Ltd. in Folsom, California, and analyzed for TVH and BTEX using US Environmental Protection Agency (EPA) Method TO-3.

Static oxygen concentrations in soil gas have increased with continued bioventing at the VW and all MP locations and depths at the site, and carbon dioxide concentrations have decreased at each location (Table 2). TVH concentrations generally increased over the 1-year treatment period, with TVH reductions in the treatment area observed only at MPA-16, MPA-32, MPB-16, MPC-24, and the VW. Some MP intervals experienced significant increases in TVH concentrations, particularly MPB-45 and MPA-45.

The increases in static soil gas oxygen concentrations are indicative of reduced aerobic hydrocarbon biodegradation activity at all these sample locations. Low oxygen levels (<10 percent) at some points indicate the continued presence of fuel contamination and the continued, but diminished, respiration activity in these soils. Decreased biodegradation is further indicated by the relatively low carbon dioxide levels present in these soils. Carbon dioxide is a byproduct of aerobic biodegradation, so concentrations similar to those initially encountered at the site would be anticipated if the degradation rate had remained stable. The reduction in the biodegradation rate over the 1-year treatment period is unexpected, especially considering the presence of sufficient oxygen and increased TVH (substrate) concentrations. The increase in TVH concentrations in the deeper soils may be attributed to fluctuations in the level of the perched groundwater table (i.e., a "smear" zone may be present), or the volatilization of hydrocarbon contaminants from the perched water layer.

All of the BTEX constituents were detected in soil gas at each of the MP intervals sampled during both the initial and 1-year sampling event (Table 2); however, the concentrations of benzene, the primary chemical of concern based on potential risk, decreased in each of the MP intervals sampled. The continued presence of benzene in soil gas indicates that a source for this chemical persists in the vadose soils and/or groundwater in the treatment area. Concentrations of toluene and ethylbenzene also decreased or remained about the same, but xylene and TPH concentrations were erratic. Xylene and TVH levels increased at MPA-45 and MPB-45 and decreased at the shallower intervals, MPB-32 and MPC-32. TVH at MPB-45 increased from 15,000 parts per million by volume (ppmv) during the initial sampling, to 21,000 ppmv after 1-year of treatment.

Respiration Test Results

An area respiration test was performed at Building 675 from 1 through 4 May 1997. A point *in situ* respiration test similar to the test performed during the initial pilot test was

attempted, but was altered to an area test because of difficulties with the testing equipment. The area respiration test was performed by injecting air into the VW for more than 22 hours to bring the oxygen levels at all MPs to (or near) 20.8 percent. After the injection was discontinued, changes in soil gas oxygen, carbon dioxide, and TVH concentrations were monitored. Observed rates of oxygen utilization were then used to estimate aerobic fuel biodegradation rates at the same MP intervals tested during the initial pilot test. Biodegradation rates were calculated using the moisture contents derived for soil samples collected during the initial pilot test activities (April 1996) to allow for direct comparisons. A porosity of 0.396 and bulk density of 1.6 kilograms per liter were used in the calculations, which are typical values for a soil consisting primarily of sand. The attached Table 3 summarizes the respiration and fuel biodegradation rates determined during the pilot test and after 1 year of operation of the extended bioventing system.

At all sampling points, the oxygen concentrations decreased very slowly throughout the test. MPC-32 oxygen levels decreased from 20.8 percent to 18.6 percent (the greatest decrease in oxygen concentrations observed in any of the MPs during this period). The observed oxygen utilization rates have decreased significantly in comparison to the initial utilization rates. Typically, this decrease is an indicator of hydrocarbon biodegradation and contaminant removal and is expected as contaminant concentrations are reduced during treatment. Decreased oxygen utilization also may result from a reduction in the bioavailability of contaminants; however, the increased TVH and BTEX concentrations detected at the 45-foot MP intervals refute this conclusion. The reduction of oxygen utilization along with the continued presence of bioavailable contaminants suggest that other factors, such as limited nutrient availability or low moisture content, may be the cause of the reduced biological activity.

Recommendations

Based on the results of the Option 1 testing event, it appears that some of the BTEX compounds may still be present in soils at concentrations that exceed the TNRCC Plan A clean-up criteria. The continued presence of benzene and high concentrations of TVH in site soil gas suggest that the remediation of soils should continue. However, it appears that air injection bioventing will no longer be an effective treatment technology due to the insignificant oxygen demand observed in fuel-contaminated soils in April and May 1997.

Parsons ES recommends that a standard air emissions exemption be submitted and that the existing blower system be reconfigured for low-flow-rate soil vapor extraction (SVE) to remove the remaining VOCs present in the soils. An SVE system would enhance the removal of volatile contaminants that persist in soils, while allowing aerobic petroleum hydrocarbon degradation to continue. Low-flow-rate SVE is currently being successfully applied by Parsons ES at an industrial site with vadose zone VOC contamination in similar soils, located within 10 miles of Building 675 at Fort Bliss. The SVE system should be monitored to determine when TVH concentrations have decreased sufficiently to allow confirmation soil sampling pursuant to site closure.

In accordance with TNRCC, site closure cannot be achieved without groundwater sampling to confirm that Plan A criteria are met in this medium. Therefore, Parsons ES also

recommends that a sample of the perched groundwater beneath the site be collected from the VW during the field mobilization to reconfigure the system.

If you have any questions or require additional information, please contact either Brian Vanderglas at (512) 719-6000 or John Ratz at (303) 831-8100.

Sincerely,

PARSONS ENGINEERING SCIENCE, INC.

JVR for BRV

Brian Vanderglas
Site Manager

John Ratz
Project Manager

REFERENCES

EA Remediation Technologies, Inc. 1991. Underground Storage Tank Closure Form, prepared for Building 675, Fort Bliss, Texas.

Hinchee, R.E., S.K. Ong, R.N. Miller, D.C. Downey, and R. Frendt. 1992. *Test Plan and Technical Protocol for a Field Treatability Test for Bioventing.* May.

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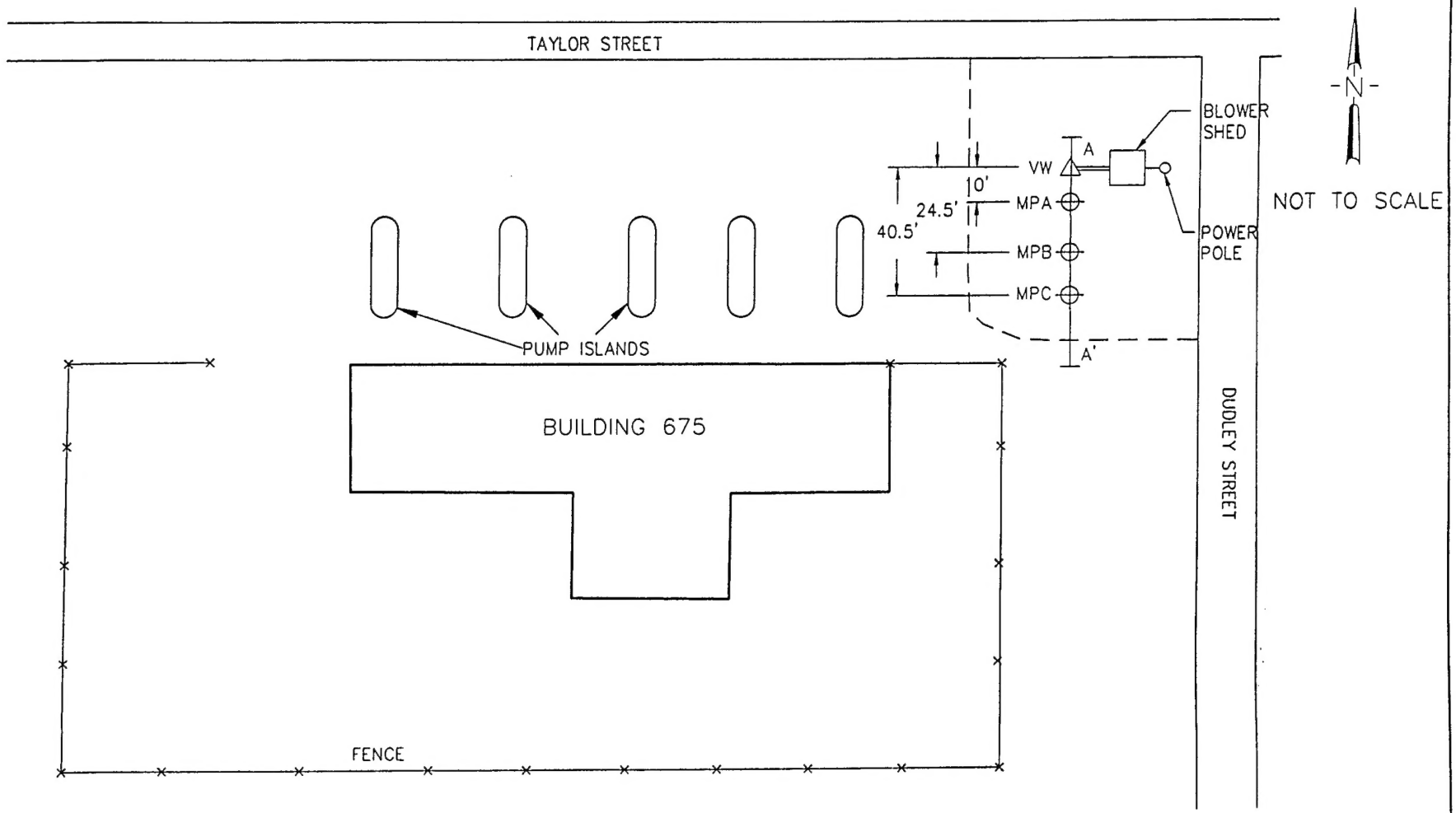
Texas Natural Resource Conservation Commission (TNRCC). 1994. Leaking Storage Tank Program, Risk-Based Corrective Action for Leaking Storage Tank Sites (RG-36). January.

cc: Mr. Gene Fabian, USAEC
Mr. Bob Lenhart, Fort Bliss
File: 726876.71110



LEGEND

△	VENT WELL
⊕	MONITORING POINT
A–A'	HYDRO GEOLOGIC CROSS-SECTION LINE

FIGURE 1

LOCATIONS OF VENT WELL, MONITORING POINTS, AND BLOWER SYSTEM COMPONENTS
LPST NO. 98508
FORT BLISS, TEXAS

PARSONS ENGINEERING SCIENCE, INC.

AB675-MP

TABLE 1
SOIL ANALYTICAL DATA
BUILDING 675, LPST NO. 98508
FORT BLISS, TEXAS

		Sample Location (depth - feet below ground surface)								
	Plan A Criteria*	VW01 (45-46)	VW01 (56.5)	MPA (37-38)	MPA(44-45)	MPB (24-25)	MPB (47-50)	MPC (23-25)	MPBG (16-17)	MPBG (31-32)
Soil Hydrocarbons										
Benzene (µg/kg)	130	U (0.4)	U (0.5)	U (212)	U (207)	U (52)	U (2940)	U (2.1)	NT	NT
Toluene (µg/kg)	69,000	U (0.4)	1.0	16000	310	1200	**190000**	U (2.1)	NT	NT
Chlorobenzene (µg/kg)	12,400	U (0.4)	0.7	2800	980	600	**22000**	U (2.1)	NT	NT
Ethyl benzene (µg/kg)	160,000	U (0.4)	1.3	13000	3100	1900	110000	U (2.1)	NT	NT
Total Xylenes (µg/kg)	568,000	U (0.4)	3.9	79000	18000	20000	550000	U (2.1)	NT	NT
1,3,5-Trimethylbenzene (µg/kg)	none	1.0	2.7	17000	9400	6900	100000	110	NT	NT
1,2,4-Tetramethylbenzene (µg/kg)	none	U (0.4)	4.9	47000	27000	17000	260000	180	NT	NT
1,2,3-Trimethylbenzene (µg/kg)	none	0.4	8.9	14000	860	5000	860000	45	NT	NT
1,2,3,4-Tetramethylbenzene (µg/kg)	none	U (0.6)	7.9	13000	10000	6400	78000	3100	NT	NT
TPH-gasoline (mg/kg)	none	U (0.1)	U (0.1)	1200	450	360	8200	37	NT	NT
TEH-extractable (mg/kg)	none	U (11.0)	U (11.0)	500	430	140	2800	150	NT	NT
Base Neutrals										
Napthalene (mg/kg)	389,000	NT	NT	2200	NT	NT	28000	NT	NT	NT
2-Methylnapthalene (mg/kg)	none	NT	NT	2600	NT	NT	30000	NT	NT	NT
Phenanthrene (mg/kg)	none	NT	NT	U (350)	NT	NT	190 J	NT	NT	NT
Soil Inorganics										
Total Kjeldahl Nitrogen (mg/kg)	none	<5.0	NT	NT	NT	<4.6	<5.0	NT	<5.1	<4.7
Total Iron (mg/kg)	none	3260	NT	NT	NT	4960	6980	NT	NT	NT
Phosphates (mg/kg)	none	85	NT	NT	NT	138	208	NT	NT	NT
Soil physical properties										
Moisture %	none	9.40	NT	NT	NT	3.04	7.50	NT	10.2	1.47
pH	none	10.18	NT	NT	NT	10.15	10.23	NT	NT	NT
Alkalinity (mg $CaCO_3$/kg)	none	269	NT	NT	NT	359	566	NT	NT	NT
Gravel (%>2 mm)	none	0.00	NT	NT	NT	4.88	1.12	NT	NT	NT
Sand (%0.75-2.0 mm)	none	96.09	NT	NT	NT	89.63	77.69	NT	NT	NT
Silt and Clay (<0.75 mm)	none	3.94	NT	NT	NT	5.49	21.19	NT	NT	NT

NT = not tested
U = compound analyzed for, but not detected. Detection limits in parenthesis.
J = indicates an estimated value when the compound is detected, but is below the EPA Estimated Quantitation Limit (EQL).
* = TNRCC Plan A Target Concentrations/Beneficial Use I Groundwater, Groundwater-Protective Soil Concentrations.

TABLE 2
INITIAL AND 1-YEAR SOIL GAS FIELD AND ANALYTICAL RESULTS
BUILDING 675, LPST NO. 98508
FORT BLISS, TEXAS

		Field Screening Data			Laboratory Data				
Sample Location	Sampling Event	O_2%	CO_2%	Field TVH (ppmv)	Benzene (ppmv)	Toluene (ppmv)	Ethyl Benzene (ppmv)	Total Xylenes (ppmv)	TVH (ppmv)
MPA-16	Initial[1]	11	6.5	2,000	--	--	--	--	--
	1-year[2]	19.5	0.4	30	--	--	--	--	--
MPA-32	Initial[1]	0	11.1	2,100	--	--	--	--	--
	1-year[2]	17.5	0.8	1,100	--	--	--	--	--
MPA-45	Initial[1]	0	12	550	110	270	33	146	5200
	1-year[2]	16	0.8	6,000	35	270	80	320	14,000
MPB-16	Initial[1]	11.5	6	2,200	--	--	--	--	--
	1-year[2]	15	1.1	82	--	--	--	--	--
MPB-32	Initial[1]	0	12	1,600	130	560	140	610	9900
	1-year[2]	8	4	2,800	2.5 M	16	7	24	4,500
MPB-45	Initial[1]	0	13	450	230	910	210	940	15,000
	1-year[2]	9.5	2.5	10,000	73	500	240	1,000	21,000
MPC-16	Initial[1]	7.2	8	570	--	--	--	--	--
	1-year[2]	13.8	3	750	--	--	--	--	--
MPC-24	Initial[1]	1.5	11.5	1,400	--	--	--	--	--
	1-year[2]	7	5	780	--	--	--	--	--
MPC-32	Initial[1]	0	12.5	1,500	120	520	190	1,000	8,500
	1-year[2]	6	4.5	2,600	5.6	29	20	140	5,600
MPBG-16	Initial[1]	20.5	0.8	250	--	--	--	--	--
	1-year[2]	20.5	0.8	33	--	--	--	--	--
MPBG-24	Initial[1]	20	1	290	--	--	--	--	--
	1-year[2]	20	1	30	--	--	--	--	--
MPBG-32	Initial[1]	20	1.1	360	--	--	--	--	--
	1-year[2]	20	1	596	--	--	--	--	--
VW	Initial[1]	14.8	4.5	1,500	34	32	8.8	47	1400
	1-year[2]	19.2	0.6	440	--	--	--	--	--

[1]Samples collected at start of extended bioventing system installation: April 14, 1996.

[2]Samples collected after one year of extended bioventing system operation: April 29, 1997.

M-Report value may be biased due to apparent matrix interferences.

--=Not sampled.

TABLE 3
RESPIRATION AND FUEL BIODEGRADATION RATES
BUILDING 675, LPST NO. 98508
FORT BLISS, TEXAS

Location-Depth	Initial = April 1996			1-Year = April/May 1997		
	Ko ($\% O_2$/min)	Degradation Rate (mg/kg/year)[a/]	Soil Temperature (°C)	Ko ($\% O_2$/min)	Degradation Rate (mg/kg/year)	Soil Temperature (°C)
MPA-16	NM[b/]	NM	21.2	NM	NM	20.1
MPA-45	0.0035	1076	22.1	0.00024	76	22.8
MPB-32	0.0039	1696	NM	0.00062	270	NM
MPB-45	0.0039	1331	NM	0.00061	210	NM
MPC-32	0.0039	1696	NM	0.00075	327	NM

[a/] Milligrams of hydrocarbons per kilogram soil per year.

[b/] NM=Not measured.

NOTE: Assumes moisture content of the soil for initial and one year calculations remains the same.

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